

The effect of Short-term Plyometric Training Program on Sprint, Strength, Power and Agility Performance in non-athletic Men

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Plyometric training to increase physical ability and leads to increase of muscles power. The aim of the study was to assess the effects of short term plyometric training program on sprint, strength, and power and agility performance in non-athletic men. In this research, 40 non-athletic men (year 18-23) participated. The participants were chosen randomly and they participated in four tests strength (Swedish swimming, sit-ups), power (vertical jumps, Horizontal jumps), agility (Illinois Agility Test, T Agility Test) and 30 meters speed. The participants were divided into two groups, i.e. experimental (plyometric training) and control group (did not perform PT training). They participated in the training for 5 weeks and each week 1 session and each session 90 minutes. The results of the study revealed that in experimental groups, significant increase observed in Swedish swimming, horizontal jumps test and also significant decrease observed in 30 meters speed and test in comparison with control group (p-value of the respectively 0.001, 0.02, 0.00). The differences were significant not observed of agility test in comparison with control group. Conclusion: Therefore, it seems that plyometric training have been effective on the physical preparation indices and can improve the non athletes' performance.

Key words: Plyometric training, Sprint, Strength, Power, Agility.

Plyometric training (PT) is popular between individuals involved in dynamic training and PT such as jumping; hopping, skipping and bounding are performed with a goal to increase dynamic performance of muscles¹. Several study

have shown the programs of PT, to increase physical ability and such training leads to increase of muscles power and boosts explosive needs in the bodies. Camp *et al.*² have studied the effects of PT on body composition; explosive strength and speed shoot in gat women footballers. The athletes have trained 3 times a week for 12 weeks and finally then study have shown that in the experimental group (PT), a significant increase was seen in the ability to jump after 6 weeks and also shooting speeds increase significantly after 12 weeks, respectively, in this study, the PT have

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no significant effects on body composition². The factors such as power and acceleration have the range of motion exercises that are useful for many sports movement³. According to previous studies, this method in PT can be currently most useful training to increase the explosive power in athletes^{4,5} is the requirement for athletes to achieve high levels of performance. Plyometric training is a training strategy designed to improve the performance by incorporating the basic needs of agility and power, allows muscle to reach exponential increase in the maximum strength and speed of movement in the shortest duration⁶⁻⁹. A study done by Mondal and Wondirad (2014)¹⁰, to assess the effect of 6-week Plyometric training on vertical jump performance demonstrated a significant improvement in the vertical jump performance of an athlete¹¹. Also, Asadi(2013), in his study concluded that a 6-week in season Plyometric training program had positive effects for improving power and agility, performance in young male basketball players¹². However, other research demonstrates that PT has positive effect on the vertical jump¹³⁻¹⁵.

Researchers have reported some improvements regarding the advantage of greater speed, a great deal of research has focused on the development of Sprint performance using a myriad of training methods, including speed training, sprint drills, sprinting against resistances, weight training, combined resistance and speed training, and PT¹⁶. The effects of PT may be different depending on the various subjects' characteristics, such as strength training level¹⁷, gender¹, age^{18, 19}, sport activity. Researchers have used several combinations of these variables¹⁶; therefore, it is unclear to consider the optimal combination of these factors for maximum achievement. In addition, meta-analyses can be applied for the factors partly responsible for the variability in treatment effects Observed among different training studies^{1, 16}. PT has been applied in numerous studies, and there is a general consensus that it improves sport specific skills such as agility³. Thus the aim of this study was to investigate the effect of short term Plyometric training Program on sprint, strength, and power and agility performance in non-athletic men.

MATERIALS AND METHODS

Participants

This quasi-experimental study, Twenty four males were recruited and randomly assigned to a plyometric training (PL, n= 12) (age = 21.9 \pm 1.7 years; body mass = 75.2 \pm 2.7 kg; body height = 180.6 \pm 3.63 cm) or control group (n =12) (age = 22.7 \pm 1.4 years; body mass = 78.6 \pm 3.1 kg; body height = 180.6 \pm 3.7 cm). All participated in the training for five weeks and one session each week and 90 minutes of each session. Before any training and testing an oral explanation of the experimental procedures was given to all participants. After this a written informed consent form was signed according to the declaration of Helsinki and subjects agreed to participate in the experiment which was approved by the University Ethics Committee. All participants were familiarized with the test exercises at least one week before the beginning of the experiment. None of the participants reported current injuries of the spine or the lower extremities and no injuries occurred during the experiment.

Procedures

A five-week period was applied for PT program, followed by post-exercise tests, three days after the last training session. During the experiment, all participants continued their regular training routine, that was identical for every participant and control group did not the exercise tests. All testing sessions began with a standardized aerobic warm up (ten minutes) followed by stretching of the lower extremity muscles. The participants warmed up with their usual routine for training. This comprised ten minutes jogging, stretching, performing 8 to 10 running drills into different directions, and 4 to 6 sub maximal running strides. The plyometric drills in the experimental group were always executed immediately after the warm-up, before any other training tasks were performed on the given day.

Agility

It has been previously suggested that PT improves specific agility in sports where sudden movements (accelerations, stops and direction changes) are required (20). Two specific agility tests were performed in the present study. The T agility test (TAT) was applied to measure agility

during direction Changes such as forward sprints³. In this test three cones were set five meters apart on a straight line and a fourth cone was placed ten meters from the middle cone, forming a T shape. The Illinois agility test (IAT) was utilized to measure agility during sprints including direction changes without stopping, and running at different angles³. Additional information about these tests has been reported by Miller *et al.* (2006). Participants performed two trials of each of the agility tests with five minutes recovery between trials, and ten minutes recovery between test types. The best time of the two trials was considered for later analysis. Times to complete the agility tests were measured every time by the same three assisting people using a stop watch. The times average were measured by the three assistants for statistic analysis. Until the end of the study the experimental status of the participants (PL or control) was unknown for all assistants.

Strength performance

Sit Ups Test

The athlete warms up for 10 minutes and lies on the mat with the knees bent, feet flat on the floor and their hands on their ears where they must stay throughout the test. The assistant holds the athlete's feet on the ground and gives the command "GO" and starts the stopwatch. The athlete sits up touching the knees with their elbows, then returns back to the floor and continues to perform as many sit-ups as possible in 60 seconds. The assistant keeps the athlete informed of the time remaining and counts also records the number of correct sit-ups completed in the 60 seconds and uses this recorded value to assess the athlete's performance.

Swedish swimming

The athlete warms up for 10 minutes and lies on the ground, places their hands by the shoulders and straightens the arms (start position). The athlete lowers the body until the elbows reach 90° and then extends the arms to return to the start position and continuous this press-up action, the assistant counts also records the number of correct press-ups completed in the 60 seconds.

Sprint performance

Subjects sprinted on a track for 30 m. In normal play, a sprint usually starts from a standing or jogging position, but in our tests, and subjects

began the sprint from a stand position stopwatch, and the end time of 30-meter was recorded. The participants have performed two minute- rest period between each test three times. The best of three trials was recorded.

Power performance

Standing Horizontal Jump

The participant stood motionless with the toes stringed level with the start line and were instructed to push off strongly and jumped forward as far as possible. Participants were allowed the use of a counter movement with arms and body swing. The distance jumped from the start line at take-off to the point where the back of the heel nearest to the take-off line landed was measured in centimeters using a metal tape measure. The test was repeated 3 times, and the maximum distance achieved was recorded in centimeters and used for analysis^{21,22}.

Vertical Jump Performance

The vertical jump height was measured with a contact mat system (New test 2000, Finland). All subjects completed a controlled warm-up consisting of jogging and stretching and 3 practice jumps at sub maximal effort. Each subject was allowed 3 test jumps with a 3-minute recovery between each jump. The maximum distance achieved was recorded in centimeters.

Plyometric training

The training program was based on recommendations of intensity and volume from Ba *et al.*²³, using similar drills, sets, and repetitions. Training volume ranged from 80 foot contacts to 100 foot contacts per session while the intensity of the exercises increased for four weeks before tapering off during week five as recommended by²⁴ and used previously in another study²⁵. The intensity of training was tapered so that fatigue would not be a factor during post-testing. The PT group trained at the same time of day, one day a week, throughout the study. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise. Specific details of the PT program are presented in Table 1.

Analyses

After confirming the data normal distribution using Kolmogorov-Smirnov test, raw data were analyzed using SPSS version 18 (version 18, SPSS Inc., Chicago, IL) and average data were

analyzed using sample t-test independent at a significance level of $P < 0.05$ was considered.

RESULTS

Results of the study showed that, power tests in the PT horizontal jump a significant

increase and vertical jump showed no significant increase compared to the control group ($p = 0.02$, $p = 0.08$) (Table 2). Results of the study showed that, in the PT group, 30 meters run test, they showed a significant decrease compared with control group ($p = 0.001$) (Table 2). Also agility tests in the PT (Illinois and T agility test) was non-

Table 1. Plyometric Five-week training protocol

Training Week	Training Volume (foot contacts)	Plyometric Drill	Sets × Reps	Training Intensity
Week 1	80	Side to side ankle hops	2 × 12	Low
		Standing jump and reach	2 × 12	Low
		Front cone hops	5 × 4	Low
Week 2	100	Side to side ankle hops	2 × 10	Low
		Standing long jump	5 × 6	Low
		Lateral jump over barrier Double	2 × 10	Medium
		Double leg hops	3 × 8	Medium
		Lateral cone hops	2 × 8	Medium
Week 3	100	Diagonal cone hops	4 × 8	Low
		Standing long jump with lateral sprint	4 × 6	Medium
			2 × 9	Medium
		Lateral cone hops	4 × 7	High
		Single leg bounding	4 × 4	High
		Lateral jump single leg		
Week 4	100	Diagonal cone hops	2 × 5	Low
		Standing long jump with lateral sprint	4 × 4	Medium
			4 × 5	Medium
		Lateral cone hops	4 × 7	Medium
		Cone hops with 180 degree turn	4 × 5	High
		Single leg bounding	2 × 7	High
		Lateral jump single leg		
Week 5	100	Diagonal cone hops	2 × 10	Low
		Cone hops with change of direction sprint	4 × 6	Medium
			3 × 4	Medium
		Double leg hops	4 × 6	High
		Lateral jump single leg		

Table 2. The effect of Short term PT Program on sprint, Strength, Power and Agility Performance

Variable	Plyometric Group(n=12)		Control Group (n=12)	
	Pre-test	Post-test	Pre-test	Post-test
Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Standing Horizontal Jump(cm)	204.52±15.48	214.37±13.85	1.96±0.23	2.05±0.22
Standing Vertical Jump(cm)	38.09±10.30	43.97±11.89	43.73±5.39	46.8±5.58
30 meters speed(s)	5.81±0.44	5.11±0.39	5.56±0.6	5.11±0.6
sit-ups(s)	40.09±9.72	43.87±9.14	40.54±4.89	41.42±7.22
Swedish Swimming(s)	26.23±7.8	34.66±8.18	32.21±9.47	34.26±8.21
Illinois Agility Test(s)	20.55±1.85	19.6±1.44	20.39±1.62	19.51±1.53
T Agility Test(s)	12.49±1.14	11.99±0.98	12.23±1.01	11.82±1.02

Significant different between pre-and post-test ($P \leq 0.05$) m

(Cm=centimeter, S=second)

significantly reduced compared with the control group ($p = 0.13$, $p = 0.06$) (Table 2). Results of the study showed that in the PT, strength factor (swimming Swedish) increased significantly and sit-ups test increased non-significantly compared with the control group ($p = 0.001$, $p = 0.18$) (Table 2).

DISCUSSION

The findings of this study revealed that five weeks of PT would improve power, speed, strength, and agility in non-athletic men. The first finding of the study showed that the PT increased significantly in the horizontal jump test and no significant increase in vertical jump test than the control group. The results of the current research are consistent with are consistent with other studies^{19, 13, 26, 27, 28, 29, 15}.

Such change in only five weeks in our study strengthens previous evidence that plyometric exercises can improve vertical jump performance in a short period of time³⁰. As previously suggested, positive changes in power, after such a short training period as in the present study, can be associated with the neural components of adaptation: specifically with an increased neural drive to the agonist muscles and changes in the muscle activation strategies (i.e. improved inter muscular coordination), or changes in the mechanical characteristics of the muscle-tendon complex³¹.

These neurophysiologic changes together may improve the ability to store and release elastic energy during the stretch-shortening cycle. Specifically, upon landing after a depth jump, an increased level of pre-activation enables the muscle sarcomeres to maintain their length, while the tendons keep elongating and store elastic energy³².

The second finding of the study showed that PT is effective on the 30 meters run and reduce its time. This result of the study is according to the findings of Meylen *et al* (2009), Sedano *et al* (2011),^{18, 15}. It appears that in the PT, the speed of converting outward contraction to inward contraction increases, the created tension by the muscle and the production power of the muscle potentially increases, therefore reduce in the time of speed run and improvement in other sports have been partly attributed to the outward-

oriented training programs and using elasticity feature of muscles. On the other hand, since in the PT, the muscles are firstly encountered outward contraction and immediately inward contraction and with shortening this phase, stronger inward contraction can be created³³, the potential energy stored in the fibers, in the inward contraction, is released and calls a greater number of muscle cords. Moreover, Thomas, French and Hayes have done their exercises twice a week which appears that three session of exercise a week will have better results and places the optimum pressure upon the player¹⁹.

The third finding of the current research revealed that PT have low effect on the Illinois and T-agility test and reduce its time. Fewer studies examined the effects of PT on specific agility, but results are more consistent in contrast with those obtained from sprint tests. Thomas *et al.*¹⁹ found that despite that sprint time was unchanged; six weeks of PT significantly improved agility (9%) in semiprofessional adolescent soccer players. The greatest improvement in agility (10%) was found in children soccer players after 8 weeks of PT¹.

Miller *et al.* (2006)³ found 5 and 3% improvements in the T agility and Illinois agility tests, respectively, after 6 weeks of PT. These improvements are greater than those obtained in the present study; however, making a comparison is difficult as training status of the participants is not reported in the study by Miller *et al.* (2006)³. It appears that the agility beneficial effects after PT can be attributed to neural adaptation, specifically to increase inter muscular coordination. Previous research also demonstrated increased proprioception after PT³⁴.

The forth finding of the study showed that Swedish swimming test increased significantly in the PT and non-significant increase in sit-ups test compared with the control group. Andrejic *et al.* (2012) in their study compared the effects of two types of short-term strength training and plyometric combination of power and ready to run in the teen's basketball payment. The results of this study indicate that this is a short-term plyometric and resistance training program for teenage basketball player improves motor function³⁵.

Asadi *et al.* (2012) effect of water and land PT on strength, speed and balance in young basketball players investigated. Finally there were no significant differences between groups in any of the variables plyometric land and in the water there. Possible reasons for this discrepancy in results may differ in duration and intensity plyometric-type exercises, participants are and how to assess anaerobic power³⁶.

Rønnestad *et al.* (2008)³⁸ demonstrated 25% gain in 1RM squat in male Norwegian first league soccer players after 7 weeks of training, but in the program strength and PT were combined, therefore their results are not surprising³⁷. A suggestion has been made previously that subjects in either good or poor physical condition benefit equally from PT work³⁸. Therefore training volume of less than 10 weeks and with more than 15 sessions, as well as the inclusion of high-intensity programs, with more than 40 jumps per session, was the strategies that seem to maximize the probability to obtain significantly greater improvements in leg muscle strength³⁸.

CONCLUSIONS

According to the results of the present study, after 5 weeks of plyometric training showed a significant increase in the horizontal jump and swimming Swedish and also a significant decrease in the 30 meters run test. Thus plyometric training has been effective on the physical preparation indices and can improve the non athletes' performance.

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